Self-cleaning and air purifying cement based GRC panels used in Tüpraş Rub project

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Abstract

Although the integration of Nano technology to cement industry is relatively new, especially white cement producers has a preference to adopt this technology to their existing products. As one of the leading special cement manufacturer Çimsa had developed a new type of cement; Çimsa self-cleaning and air purifying white cement.

The first real-time field application of this cement is Fibrobeton's new project. The automation building of the Tüpraş Petroleum Refinery. The facade of the building is covered by tailor made GRC elements in which Çimsa self-cleaning white cement were preferred. The trademark name of this innovative façade element is Fibro-T

The concrete mix in the project was highly hard to manage due to the architectural constrains. The amount of filler materials was increased from 20% to 40%, which results in workability and slump loss problems. On the other hand due to the nano integrated white cement open time of the mortar reduce from 45 minutes to 15 minutes. Early strength of the new cement based mix was increased 10% than the control mix.

One of the most important tests applied to the mix was the determination of heat released during the hydration. The results of the test show that, using new type of cement increased the heat release by 25% in first 6 hours and cause premature hydration in the mix.

Also the effectiveness of the material in terms of the photocatalytic reaction was tested according to the ISO standard, and the results showed that GRC panels emit %66 of the NOx particles whereas the control sample only emits 10%.

Keywords
GRC, nano, photocatalytic, white, cement, precast, hydration

INTRODUCTION

LEED certificated buildings become more and more important and popular all around the world. This study gives unique information about a unique project with many technology developer partners such as Çimsa Cement Co. and Fibrobeton.

In this project Fibrobeton developed a unique glass fibre reinforced concrete solution; self-cleaning environmental friendly panels for an industrial building first time in the World.

Primary reason of the selection of Fibro-T, self-cleaning concrete panels is its ambient conditions. Since the building is in the middle of a refinery it will endure most harsh environment such as NOx and SOx emissions.

The GRC panels preferred in this project; is very hard to develop due their fine material content and the heat release due to the Nano cement inside.

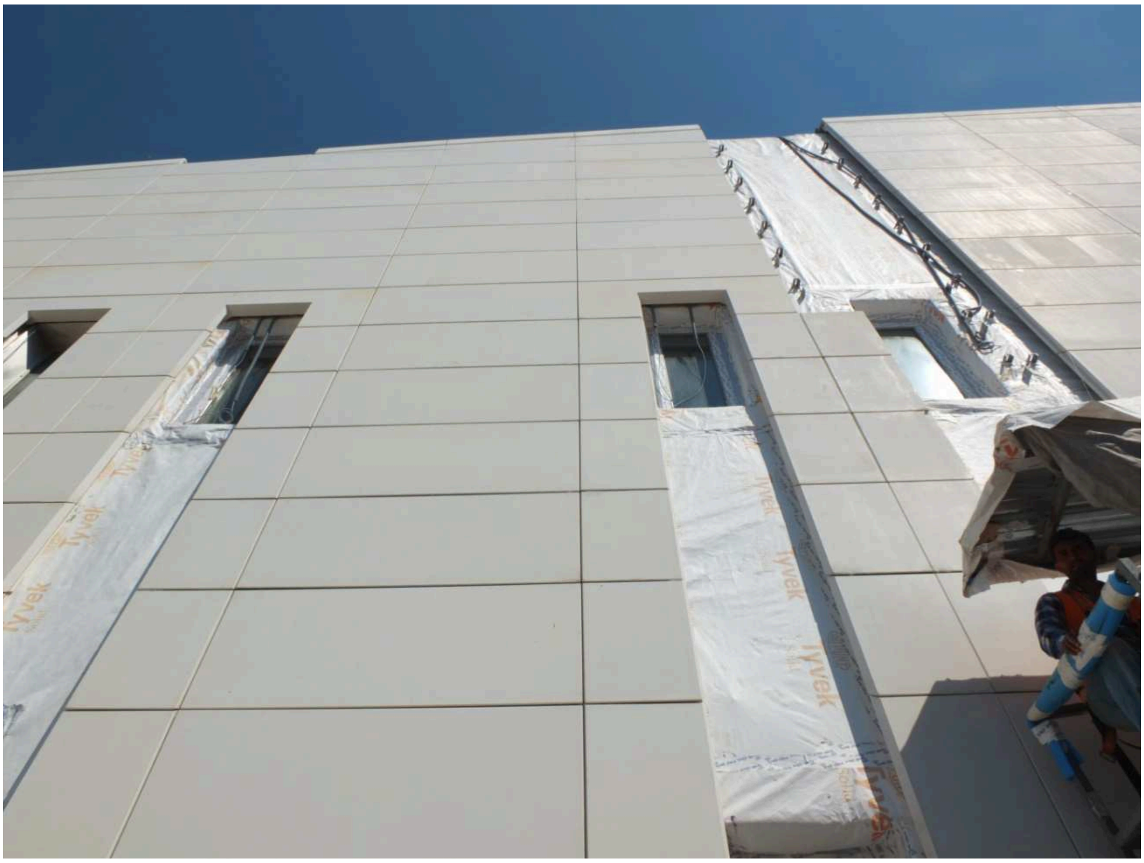

Figure 1. *Façade of the Tüpraş RUB*

Çimsa Self Cleaning cement used in the panels was developed by Çimsa with optimized nano material content in order both for supreme self-cleaning and air purifying properties.

ÇIMSA SELF-CLEANING AND AIR PURIFYING WHITE CEMENT

Starting from 1999, Çimsa is one of the leading white cement manufacturers, exporting to more than 60 countries worldwide. Çimsa is producing CEM I 52.5R type OPC and CEM II/B-L 42.5R type OPC.

In year 2012 Çimsa developed a new patented cement type which have both self-cleaning and air purifying properties with sustaining superior whiteness and strength.

The chemical, physical and mechanical properties of Çimsa self-cleaning, air purifying white cement are given in Table 1.

Table 1. *The chemical, physical and mechanical properties of Çimsa self-cleaning, air purifying white cement*

Chemical Composition (%)		Physical and Mechanical Properties	
Insoluble Residue	0,18	2 Compressive Strength (MPa)	30,1
	21,6		
	4,08	28 Compressive Strength (MPa)	53,2
	0,3	Density (g/)	3,03
CaO	65,6	Initial Setting Time (min)	90
MgO	1,03	Blaine Fineness (/g)	5200
	3,26	Whiteness (Hunter Lab Y Scale)	88.2
Loss on Ignition	3,2		
	0,17		
	0,46		
Cl^-	0,008		

The mechanism of the self-cleaning has been demonstrated that both organic pollutants and oxides such as NO, and at low concentration levels can be treated by under UV irradiation. The reaction begins with the irradiation of light over . When TiO= absorbs a photon containing the energy equal to or larger than the band gap, an electron will be promoted from the valence band to the conduction band.

The activation of the electrons results in the generation of ''holes'' (electron vacancy) in the valence band. In this reaction, hş and e_ are powerful oxidizing and reducing agents respectively. The electron–hole pairs may recombine in a short time or take part in chemical reactions depending on reaction conditions and molecular structures of the semiconductors.

The strong oxidation power of hş enables it to react with water to generate the highly active hydroxyl radical (OH) which is also a powerful oxidant. Most organic air pollutants can be degraded completely by either the hydroxyl radicals or the holes themselves to innocuous final products (e.g. and). In addition, the reducing power of the electrons can induce the reduction of molecular oxygen ( ) to superoxide ( ). It has been confirmed that the superoxide is almost as effective as the holes and hydroxyl radicals in the chain reactions for the breaking down of organic compounds.

The tests for the effectiveness of photocatalytism have been determined according the ISO 22197 standard; Fine ceramics (advanced ceramics, advanced technical ceramics) -- Test method for air-purification performance of semiconducting photocatalytic materials -- Part 1: Removal of nitric oxide.

The tests for the effectiveness of the cement in GRC panels were carried out in Middle East Technical University. The test procedure based on the determination of the air-purification performance of materials that contain a photocatalyst or have photocatalytic films on the surface, usually made from semiconducting metal oxides, such as titanium dioxide or other ceramic materials, by continuous exposure of a test piece to the model air pollutant under illumination with ultraviolet light. It is not suitable for the determination of other performance attributes of photocatalytic materials, i.e., decomposition of water contaminants, self-cleaning, antifogging and antibacterial actions.

The tests showed that GRC panels manufactured with Çimsa self-cleaning, air purifying white cement absorbed NOx molecules 4 times more than the regular white cement in a definite period of time

The usage of Çimsa self-cleaning, air purifying white cement in GRC panels is directly related with the conditions of the application area. In big cities with dense population the pollutant concentration at street level is quite high because the dispersion of the exhaust generated by a large number of vehicles is hindered by the surrounding tall buildings. For these cities applying TiO2 modified cementitious materials onto the external covering of buildings or roads may be a good supplement to conventional technologies such as catalytic converters fitted on the vehicles for reducing gaseous exhaust emission.

Concrete pavement surfaces and external building surfaces are optimal media for applying the photocatalytic materials because the relatively flat configuration of the building materials can facilitate the exposure of the photocatalyst to sunlight. In addition, the nature of cement matrix is particularly suitable for incorporating TiO2 particles and other photo-oxidation products. Under irradiation of solar light, gaseous pollutants can be degraded on the surface of construction materials which can be eventually washed away by rain. The whole removal process of pollutants is driven by natural energy alone.

FIBRO-T: SELF CLEANING AND AIR PURIFYING GRC PANELS

Fibro-T is designed by Fibrobeton Company in order to combine functionality, aesthetics and performance, see Figure 2.

Figure 2. *Fiber-T Panels*

In the design stage of the Fibro-T; high water demand is controlled with hyper range plasticisers. The brightness of the panels has to be higher than the regular GRC elements, in order to achieve this finer sand gradation preferred. Maximum aggregate size of the Fibro-T is 30% lower than the regular panels. Micron size calcite is also maximized for brightness. Fibre addition for minimizing cracks is also vital for an element which is vulnerable to plastic shrinkage cracks. The micro fibre amount is 0.2%

Mechanical properties of the Fibro-T are also enhanced due to the special mix design. Lower w/c ratio, finer gradation and Çimsa Nano cement leads to a strength increase. The relative comparison graphs for standard GRC panels and Fibro-T are given in Figure 3.

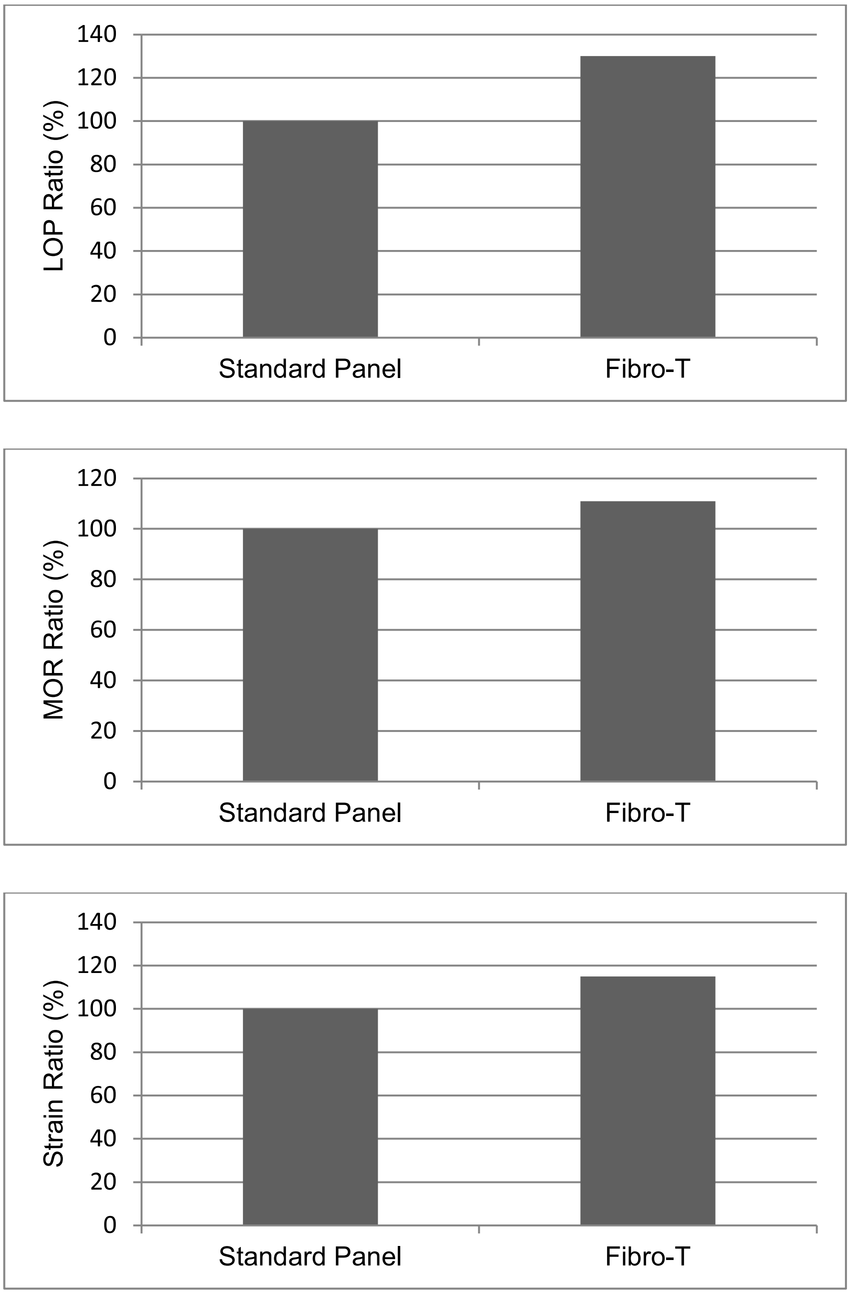

***Figure 3**.Comparison of standard panels and Fibro-T in terms of LOR, MOR and Strain Ratio*

TÜPRAŞ RUB PROJECT

Tüpraş Automation building is unique due to its position. Its façade has unique whiteness although it is in the middle of a petroleum refinery.

Figure 4. *General view of Tüpraş RUB*

The building is vulnerable to NOx, SOx emissions as well as petroleum by-products. Fiber-T panels were selected in order to prevent dirt deposition on the surface of the panels and to sustain long term whiteness.

Tüpraş RUB project mainly consists of 2 levels. One is the façade of the building and the other one is the floor covering.

There were 2.800 GRC panels used for façade and 2000 panels were utilized for floor cover. Total covered area was 8.000 , namely 5.000 for façade and 3.000 for flooring.

The thickness of the panels was 30 mm at façade and 40 mm at the floor coverings. Total construction time for GRC manufacture was 6 months.

The change of the whiteness will be monitored periodically in order to control the effectiveness of the panels according to the Hunter Lab scale.